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ABSTRACT

In a longitudinal study conducted in Reykjavik, Iceland, 60 male and 61 female subjects were tested at 7, 8, and 9 years of age in order to investigate their comprehension of three concrete-operational concepts (conservation, class inclusion, and logical multiplication). This report focuses on a logical reconstruction of the developmental sequence of the three concrete-operational concepts. Based on a structural task analysis, a developmental model was postulated that defines the emergence and consolidation of concrete operations as a successive (cumulative) process. Empirically, all children in the longitudinal study followed an invariable developmental sequence corresponding to a unidirectional model. Methodological implications of the longitudinal design and the logical formulation of multilateral developmental models are discussed and an empirical evaluation and statistical test of the developmental model is provided. It is concluded that the findings may be viewed as additional theoretical and statistical evidence for the decalage hypothesis of the development of concrete operations. (Author/RH)

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A Model of the Development of Concrete Operations: Synchrony or Décalage?

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Abstract

In a longitudinal study conducted in Reykjavik, Iceland, subjects (121 children, 60 male, 61 female) were tested at seven, eight, and nine years of age in order to investigate their comprehension of three concrete-operational concepts (conservation, class inclusion and logical multiplication).

The present study focuses on a logical reconstruction of the developmental sequence of the three concrete-operational concepts. Based on a structural task analysis, a developmental model was postulated that defines the emergence and consolidation of concrete operations as a successive (cumulative) process. Empirically, all children followed an invariable developmental sequence corresponding to a unidirectional model. Methodological implications of the longitudinal design and the logical formulation of multilateral developmental models are discussed. An empirical evaluation and statistical test of the developmental model is provided.

Theoretical Background and Hypothesis

The present research was aimed at analyzing individual developmental paths during the acquisition of concrete operations. The analysis purports to trace intraindividual change in the domain of operational intelligence back to general formation processes. These ordered formation principles are described and explained within the theoretical framework of genetic epistemology in terms of progressive consolidation, structuring and integration (Pinard & Laurendeau, 1969). Thus, the regularities in the genesis of concrete operations can be defined as developmental sequences (Flavell & Wohlwill, 1969; Hoppe, Schmid-Schönbein, & Seiler, 1977; Wohlwill, 1973). These developmental sequences (defined as relations between variables) can be represented on a conceptual level by logical propositions (v. Eye & Brandtstädter, in press; Hoppe-Graff, 1982). For instance, if the acquisition of a concept A is a prerequisite structure for the emergence of concept B, the relation of A and B can be conceptualized as necessary condition or as logical implication.

Three concrete-operational subtasks were investigated: Conservation, class inclusion, and logical multiplication. Contrary to the assumption that qualitatively different substructures emerge synchronously (synchrony-hypothesis; Achenbach & Weisz, 1975; Little, 1972; Piaget, 1941; Inhelder & Piaget, 1967; Piaget & Szeminska, 1952), it was postulated that the three subtasks examined develop successively and cumulatively (décalage hypothesis; Brainerd,

1973; Kingma, 1983; Winer & Kronberg, 1974). The predicted horizontal décalage is based on a task analysis of the substructures. According to this analysis which corresponds to an analysis presented by Kofsky (1966), conservation is a necessary condition for the acquisition of class inclusion and class inclusion a necessary condition for logical multiplication. First: The operation of addition and inclusion of classes implies the concept of conservation since through the addition of both subclasses A1 + A2 = B the different classificatory attributes have to be conserved. Second: When comparing addition or inclusion of classes and multiplication of classes it was assumed that the second operation emerges at a later point of time because of simultaneous combination of multiple attributes. If this is true, there exist implicative relations between class inclusion and conservation, and, furthermore, between logical multiplication and class inclusion. Regarding the development of operativity, this ordered series of tasks or substructures corresponds to an invariable developmental sequence. It follows that conservation should emerge before class inclusion and class inclusion should emerge before logical multiplication.

Subjects and Procedure

The research is part of a longitudinal study conducted in Reykjavik, Iceland, since 1977 (Edelstein, 1984). Subjects were 121 children, 60 male and 61 female, from different socio-economic backgrounds. For the examination of the development of concrete operations, performance on three tasks (conservation, class inclusion, and logical multipli-

cation) was assessed at ages seven, eight, and nine. For the present purpose only the data from the 7 and 9 year old subjects will be used. Moreover, conservation was dropped from the analysis at age 9, as ceiling effects appeared. The tasks were presented in accordance with Piaget's clinical method. For the measurement of conservation, subjects were administered the "Concept Assessment Kit" designed by Goldschmid & Bentler (1968); for the examination of class inclusion and logical multiplication an adaptation of Smedslund's (1964) tasks was used.

Conceptual and Methodological Implications

Starting from the sequence hypothesis a developmental model will be presented and discussed in this section. The developmental relations within this acquisition model are formulated as logical propositions. Within the model only those progress patterns were specified that match the conditions of the décalage hypothesis.

Analyzing intraindividual change, the longitudinal design permits the distinction of two analytical perspectives. First: The synchronous perspective represents the analysis of developmental sequences within one measurement point, that is, configurations of variables within the subject. This sequence is not observed but inferred. Second: The diachronous perspective represents the examination of the observed developmental changes (constellations) across measurement occasions. The second analytical perspective necessitates longitudinal designs, because it focuses on the analysis of change across different measurement occasions.

These differentiations correspond to the distinctions within the methodological framework proposed by Buss in his 1979 paper.

Insert Figure 1 about here

On the basis of the distinction between synchronous and diachronous perspectives the postulated developmental relations can be reformulated as logical propositions. It will be remembered that three developmental relations had emerged from the task analysis (conservation is a necessary condition for class inclusion and logical multiplication, and class inclusion is a necessary condition for logical multiplication). These three developmental relations are adequately represented by the logical proposition type of implication (see Fig. 2). Logical implication does not admit the conjunction of two successively emerging variables of the following kind: "Absence of prerequisite structure A" and "Presence of later substructure B". For example, the following developmental paths would be inadmissible: Classification operations are available to the subject while conservation has not been acquired.

Insert Figure 2 about here

Logical implication, however, only matches the ordered series of variables on the synchronous level; it adequately describes the ordered set of relationships between variables

at one time of measurement (configurations). In contrast, the diachronous level of analysis focuses on the emergence of concepts across times of measurement. In this case an additional assumption has to be examined and included in the developmental model. It concerns the retention of an acquired ability. According to the notion of progressive consolidation and integration of the concrete-operational structure of the whole, it was postulated that the different substructures emerge cumulatively during development (cumulativity); that is, once an ability is acquired, it must be retained across development. This relation can be formulated as a sufficient condition which corresponds to the logical proposition type of replication (see Fig. 3). Considering the case of two measurement occasions (t1 and t2), replication implies that an ability that exists at the first time of measurement (A1) must be present on the follow-up measurement occasion (A2). For instance, the occurrence of ability A on the first measurement occasion represents a sufficient condition for the occurrence of the same ability at the following time of measurement. Note that this is not the case in most instances of psychological assessment of a trait.

Insert Figure 3 about here

The two hypotheses (transitivity and cumulativity) and the corresponding developmental relations can be summarized in a more complex model of development (see Fig. 4). This

model integrates both the synchronous and diachronous perspectives.

Results

For the statistical evaluation of the order-theoretical analyses conducted on the data, a procedure known as "scalability models" was used (Henning & Rudinger, in press). In particular, Dayton & McReady's probabilistic validation procedure (1976) was applied. This procedure permits the reconstruction of a postulated developmental model from observed developmental data. The acquisition model specifies the admissible paths of development which, in turn, are depicted as the configuration or pattern of the variables. In our case, the patterns represent the developmental paths of the children in the domain of concret-operational intelligence (the three tasks invariance, classification, and logical multiplication at ages seven and nine).

The procedure permitted a statistically significant reconstruction of the postulated model with the exception of one effect of vertical décalage (Schroeder, in press, see Tab. 1 and 2). Further details will not be discussed in this paper. It should be emphasized, however, that the effect of the vertical décalage did not contradict the postulated developmental model and the implicit hypothesis of horizontal décalage.

Insert Tables 1 and 2 about here

Conclusions and Discussion

The model of development shown in Fig. 4, which represents the formation process of the structure of the whole of concrete operations, is based on the hypothesis of horizontal décalage. Several methodological and analytical reasons necessitated the transformation of the décalage hypothesis into two separate hypotheses serving both the synchronous and diachronous perspective. The developmental relations were formulated as logical propositions since the propositional calculus was sufficient to describe the assumed developmental processes as theoretically defined.

It was demonstrated that all children of the sample followed an invariable sequence. This lends credence to the assertion that development of concrete operations and the consolidation of the structure of the whole is a unitary and unidirectional process.

On the one hand, the horizontal décalage hypothesis contradicts the assumption of a synchronous acquisition of qualtitatively different concrete-operational substructures. On the other hand, it is congruent with various empirical findings that support an ordered sequence in the acquisition of concrete operations. The consolidation of concrete operations proceeds in the form of an invariable developmental sequence. Therefore, the results obtained through the microanalytic approach presented here may be viewed as additional theoretical and statistical evidence for the décalage hypothesis of the development of concrete operations.

References

Achenbach, T. M., & Weisz, J.R. (1975). A longitudinal study of developmental synchrony between conceptual identity, seriation and transitivity. Child Development, 43, 1024-1034.

Brainerd, C. J. (1973). Order of acquisition of transitivity, conservation, and class inclusion of length and weight. Developmental Psychology, 8, 105-116.

Buss, A. R. (1979). Toward a unified framework for psychometric concepts in multivariate developmental situations. In J.R. Nesselroade & P.B. Baltes (Eds.), Longitudinal research in the study of behavior and development: Design and analysis (pp. 41-59). New York: Academic Press.

Dayton, G. M., & MacReady, G.B. (1976). A probabilistic model for validation of behavioral hierarchies. Psychometrika, 44, 189-204.

Edelstein, W. (1984). Das Projekt Kindliche Entwicklung und Soziale Struktur. In K.E. Grossmann & P. Lütkenhaus (Eds.), Bericht über die 6. Tagung Entwicklungspsychologie in Regensburg (Bd. II; pp. 275-277). Regensburg: Universität Regensburg.

v. Eye, A., & Brandstädter, J. (in press). Evaluating developmental hypotheses using statement calculus and non-parametric statistics. In P.B. Baltes, D.L. Featherman, & R.M. Lerner (Eds.), Life-span development and behavior (Vol. 8). Hillsdale, NJ: Lawrence Erlbaum.

Flavell, J. H., & Wohlwill, J.F. (1969). Formal and functional aspects of cognitive development. In D. Elkind & J.H. Flavell (Eds.), Studies in cognitive development: Essays in honor of Jean Piaget (pp. 67-120). New York: Oxford University Press

Goldschmid, M. L., & Bentler, P.A. (1968). Manual: Concept assessment kit - conservation. San Diego, CA: Educational and Industrial Testing Service.

Henning, H. J., & Rudinger, G. (in press). Analysis of qualitative data in developmental psychology. In J.R. Nesselroade & A. v. Eye (Eds.), Individual development and social change: Explanatory analysis. New York: Academic Press.

Hoppe, S., Schmid-Schönbein, C., & Seiler, T. B. (1977). Entwicklungssequenzen. Bern: Huber.

Hoppe-Graff, S. (1982). Bedingungsanalysen zur Genese der Klasseninklusion. Unpublished dissertation, Technische Hochschule Darmstadt.

Inhelder, B. & Piaget, J. (1967). La genèse des structures logiques élémentaires. Classifications et sériations. Neuchâtel: Delachaux & Niestlé.

Kingma, J. (1983). The development of seriation, conservation, and multiple classification: A longitudinal study. Genetic Psychology Monographs, 108, 43-67.

Kofsky, E. (1966). A scalogram study of classificatory development. Child Development, 37, 191-204.

Little, A. (1972). A longitudinal study of cognitive development in young children. Child Development, 43, 1024-1034.

Piaget, J. (1941). Le mécanisme du developpement mental. Archives de Psychologie, 17(112), 215-285.

Piaget, J., & Szeminska, A. (1952). The child's conception of number. London: Routledge & Kegan Paul.

Pinard, A., & Laurendeau, M. (1969). "Stage" in Piaget's cognitive developmental theory: Exegesis of a concept. In D. Elkind & J. H. Flavell (Eds.), Studies in cognitive development: Essays in honor of Jean Piaget (pp. 121-170). New York: Oxford University Press.

Smedslund, J. (1964). Concrete reasoning: A study in intellectual development. Monographs of the Society for Research in Child Development, 19(2), 93.

Schroeder, E. (in press). Sequenzanalyse konkreter Operationen. Berlin: Max-Planck-Institut for Human Development and Education.

Winer, G. A., & Kronberg, D. D. (1974). Children's responses to verbally and pictorially presented class-inclusion items and to a test of number conservation. Journal of Genetic Psychology, 125, 141-152.

Wohlwill, J. (1973). The study of behavioral development. New York: Academic Press.

Figure 1: Sequence Analysis
Synchronous and Diachronous Perspectives

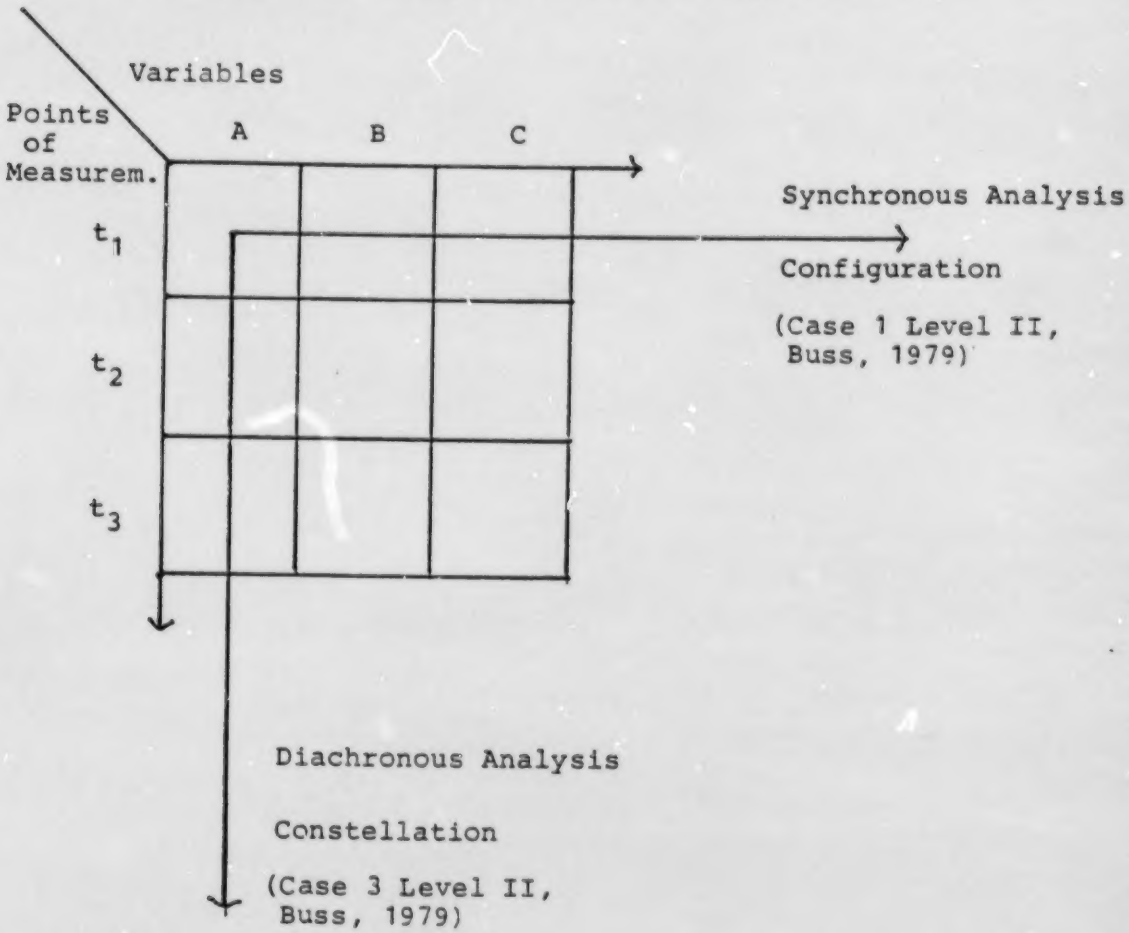
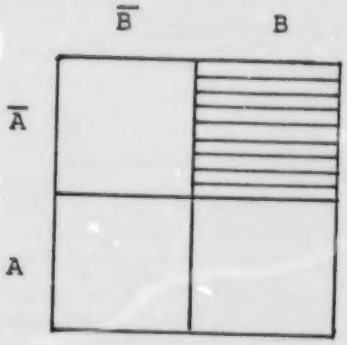


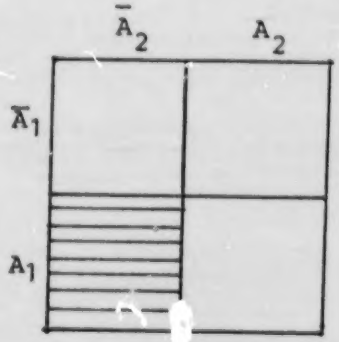
Figure 2 and 3: Types of Logical Relations and Patterns of Error in Contingency Tables



Error Pattern I

Necessary Condition

Logical Implication



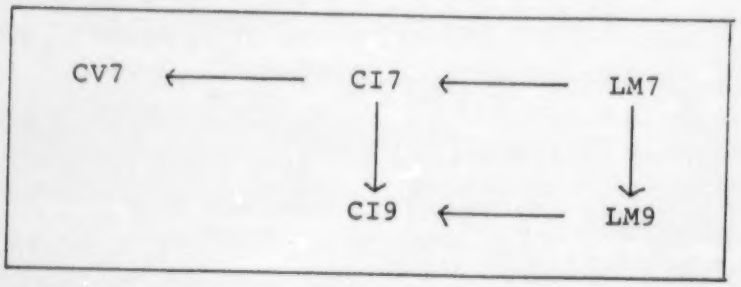
Error Pattern II

Sufficient Condition

Logical Replication

Error Celles Barred

Figure 4: Developmental Model of Concrete Operations



CV7 : Conservation (7 year-old)

CI7,9: Class Inclusion (7,9 year-old)

LM7,9: Logical Multiplication (7,9 year-old)

⟵: Necessary Condition (Tansitivity): Synchronous Level

↓ : Sufficient Condition (Cumulativity): Diachronous Level

Table 1: Admissible Patterns
in Accordance with Test Model

7-Year			9-Year		
CV7	CI7	LM7	CI9	LM9	
0	0	0	0	0	Invariant
1	0	0	0	0	I
1	1	0	1	0	I
1	1	1	1	1	I
0	0	0	1	0	Progression
0	0	0	1	1	P
1	0	0	1	0	P
1	0	0	1	1	P
1	1	0	1	1	P
1	0	1	0	1	Vertical Décalage
1	0	1	1	1	V
1	1	1	1	0	V

12 Admissible Patterns out of
32 Possible Patterns

Table 2: Statistical Parameters of Testing Model
(Procedure by Dayton & MacReady, 1976)

Pattern	Theta	Observed N	Predicted N	Chi-Square
00000	0.025272	4	3.8725	0.0042
10000	0.072291	9	8.7862	0.0052
01000		0	0.0255	0.0255
11000		0	0.3376	0.3376
00100		0	0 0595	0.0595
10100		0	0.7881	0.7881
01100		0	0.0251	0.0251
11100		0	0.3320	0.3320
00010	0.043526	6	5.8701	0.0029
10010	0.136858	16	15.7725	0.0033
01010		0	0.3376	0.3376
11010	0.039726	5	4.4716	0.0625
00110		2	0.7881	1.8636
10110	0.103947	10	10.4375	0.0183
01110		0	0.3320	0.3320
11110	0.041900	5	4.3975	0.0826
00001		1	0.2116	2.9367
10001		1	1.3973	0.1130
01001		0	0.0450	0.0450
11001		1	0.5960	0.2739
00101		0	0.0550	0.0550
10101		0	0.7286	0.7286
01101		0	0.0648	0.0648
11101		2	0.8588	1.5163
00011	0.014388	2	2.8029	0.2300
10011	0.189870	19	18.5060	0.0132
01011		0	0.5960	0.5960
11011	0.083288	8	7.8930	0.0015
00111		2	0.7286	2.2186
10111	0.104087	9	9.6496	0.0437
01111		0	0.8588	0.8588
11111	0.144848	11	11.3744	0.0123
Σ		113		χ^2 = 13.9875

obs. χ^2 = 13.9875 (18 df)

crit. χ^2 = 21.6049 (18 df and α = 75%)

alpha (α_i) ≤ 0.001; beta (β_i) = 0.07205

Pattern: Configuration (CV7-CI7-LM7-CI9-LM9)
Theta: Probability of Pattern j
Observed N: Observed Frequency
Predicted N: Predicted Frequency
alpha: "Positive Error" (Guessing Error)
beta: "Negative Error" (Forgetting Error)